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QUALIFICATION VIBRATION TEST REPORT FOR SD 802 MATERIALS EXPERI--ETC(U)

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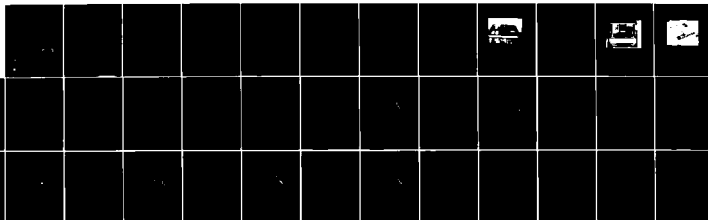
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# Qualification Vibration Test Report for SD 802 Materials Experiment

A. F. DIGIACOMO  
(Materials Sciences Laboratory)  
Laboratory Operations  
The Aerospace Corporation  
El Segundo, Calif. 90245

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Prepared for  
SPACE DIVISION  
AIR FORCE SYSTEMS COMMAND  
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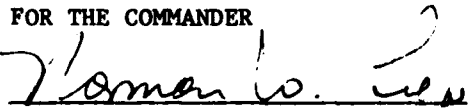
This report has been reviewed by the Public Affairs Office (PAS) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication. Publication of this report does not constitute Air Force approval of the report's findings or conclusions. It is published only for the exchange and stimulation of ideas.

  
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FOR THE COMMANDER

  
Norman W. Lee, Jr., Colonel, USAF  
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# PREFACE

The vibration tests were completed through the joint effort of the LDEF Project Office, Langley Research Center; the Test Operations Section, Goddard Space Flight Center; and the Materials Sciences Laboratory, The Aerospace Corporation.

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Project		
Task		
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## 1. TEST DESCRIPTION AND RESULTS

### 1.1 OBJECTIVE

Vibration qualification tests were performed for a representative sampling of flight hardware from the SD 802 Materials Experiment, NASA Experiment No. M003. The vibration test satisfied the flight hardware qualification test specifications as described within the test procedures drafted by C. Kiser, NASA Langley. A copy of these procedures are on file at The Aerospace Corporation, Materials Sciences Laboratory (Refs. 1 through 3).

### 1.2 HARDWARE DESCRIPTION

Flight hardware for the SD 802 Materials Experiment consists of duplicate hardware to be flown on the leading and trailing edge of the Long Duration Exposure Facility (LDEF) Spacecraft. The hardware subjected to the qualification vibration test was the fully assembled, 3- and 6-in. depth experiment trays and the test sample retention hardware that is mounted within the experiment environmental control canister (EECC). Small test articles, such as a solar module, fragile test sample material, and simulated optical test samples, were mounted within some of the hardware to ensure the integrity of the retention techniques.

#### 1.2.1 3-in. Experiment Tray Assembly

The 3-in. tray assembly contained six individual experiment modules. Modules 1 through IV consist of assembled test sample retention hardware with lead ballast added to simulate the test sample and battery mass. Modules V and VI will contain preassembled experiments so they were simply simulated by aluminum plates with the appropriate amount of lead ballast attached. The tray assembly described above is shown in Figure 1.

#### 1.2.2 6-in. Experiment Tray Assembly

Modules I and II contained a mass that simulated the experiment power and data system (EPDS) and associated batteries. The composite materials experiment assembly occupied Module III, and the signal conditioning

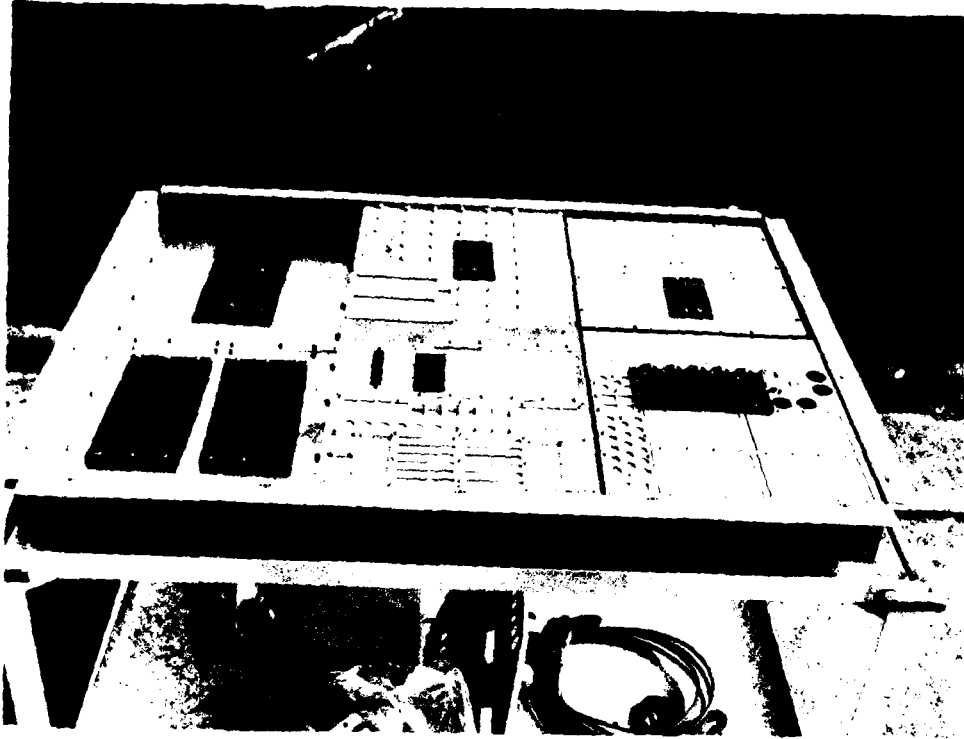


Figure 1. 3-in. Experiment Tray Assembly

electronics package was simulated with an approximate mass and located in the module IV position. Module positions V and VI were occupied by an EECC. The tray assembly is shown in Figure 2. The tray assembly is retained within a NASA designed tray handling fixture.

#### 1.2.3 EECC Drawer Hardware Assembly

The sample retention module located within the EECC drawer was mounted to a flat aluminum sheet to simulate the actual mounting within the EECC drawer. Lead ballast was added to simulate the test sample mass. The assembly is shown in Figure 3, the vibration test fixture. One-half of this one-third test fixture was used in the test.

### 1.3 TEST RESULTS

#### 1.3.1 3-in. Experiment Tray Assembly

The 3-in. tray assembly was subjected to the prescribed vibration tests as described in Section 2. Accelerometers were mounted at the approximate center of the sample retention plates on modules III and IV. The accelerometers were used to monitor vibration along each of the three mutually perpendicular axis (Figure 4). Vibration data recorded during the sine and random vibration tests were reviewed. The sinusoidal vibration sweep record for each axis tested shows the fundamental mode of vibration occurring above the upper frequency limit established for the sine qualification test. Random vibration power spectral density plots for each axis show that the test articles have been subjected to, or slightly greater than, the 10.96 g-rms test level. The final visual examination of the hardware and experiment tray produced no evidence of structural damage.

#### 1.3.2 6-in. Experiment Tray Assembly

The 6-in. tray assembly was subjected to the prescribed vibration tests as described in Section 2. Three accelerometers were mounted at the approximate center on the bottom surface of the sample tray assembly, module III. The accelerometers monitored vibration along each of the three mutually perpendicular axes. Both the sine and random vibration test requirements were completed in the L-axis and M-axis of the tray (Figure 5). The N-axis sine



Figure 2. 6-in. Experiment Tray Assembly

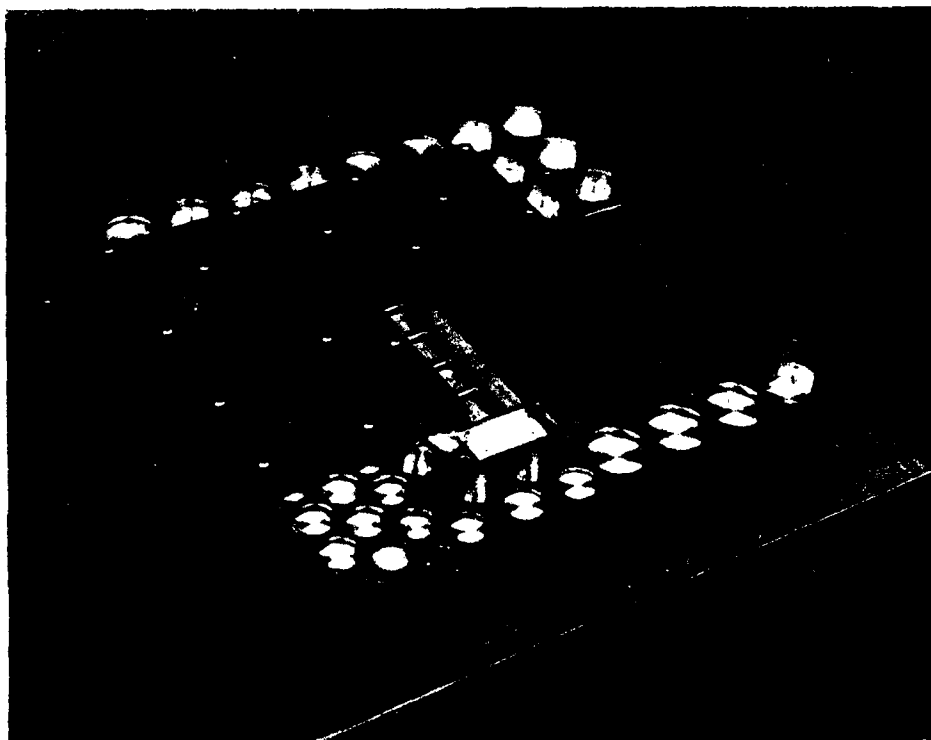


Figure 3. EEEEC Drawer Hardware Assembly

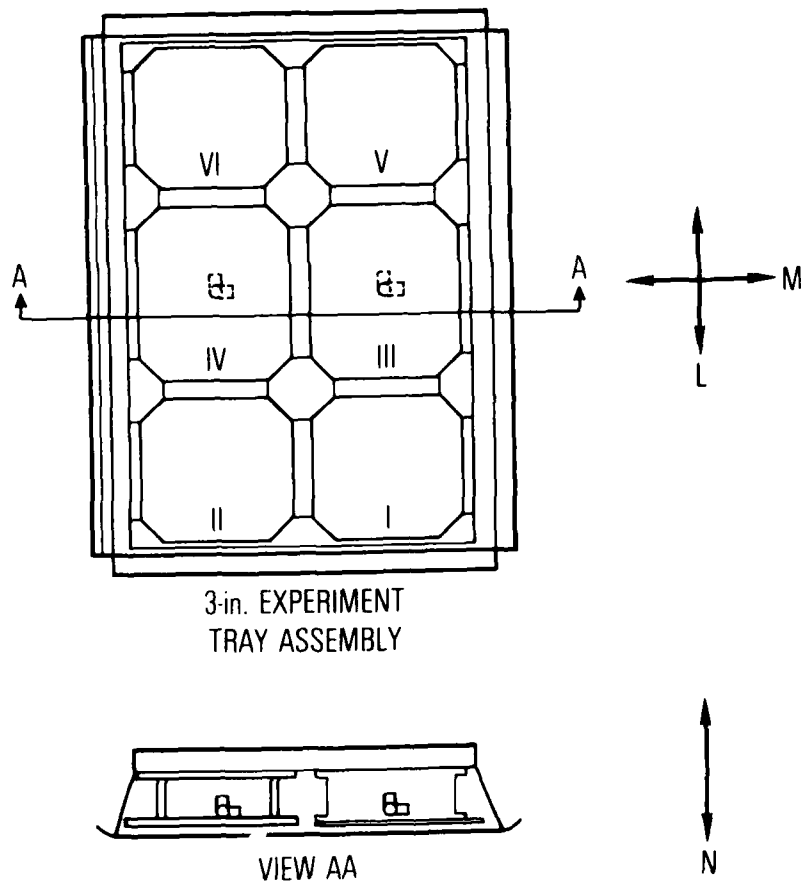


Figure 4. 3-in. Experiment Tray Assembly Accelerometer Location and Vibration Axis Designation

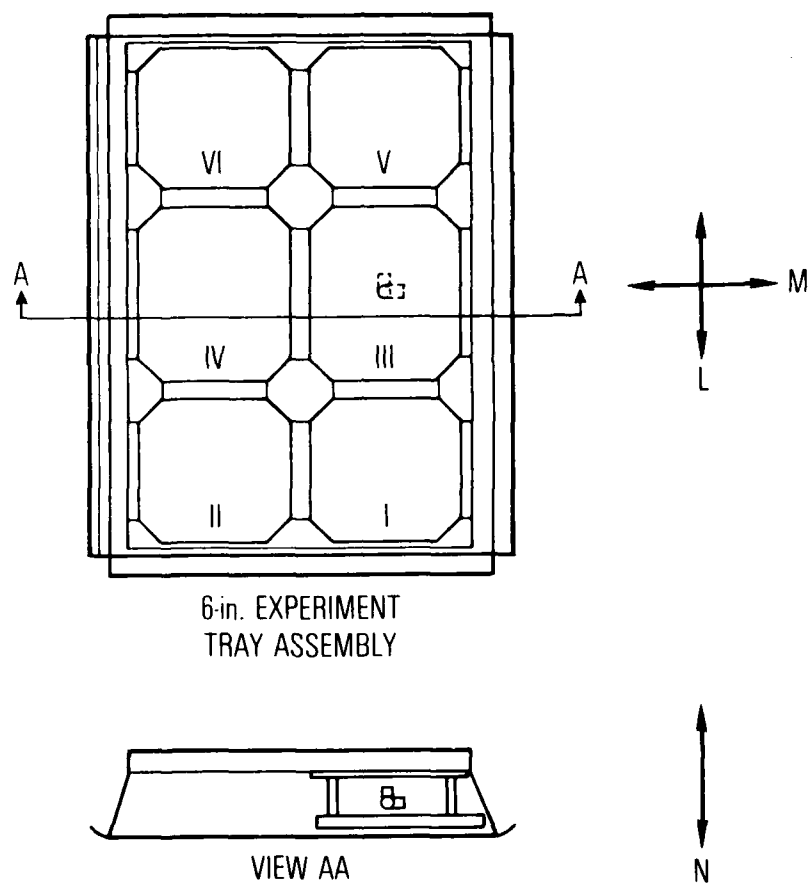


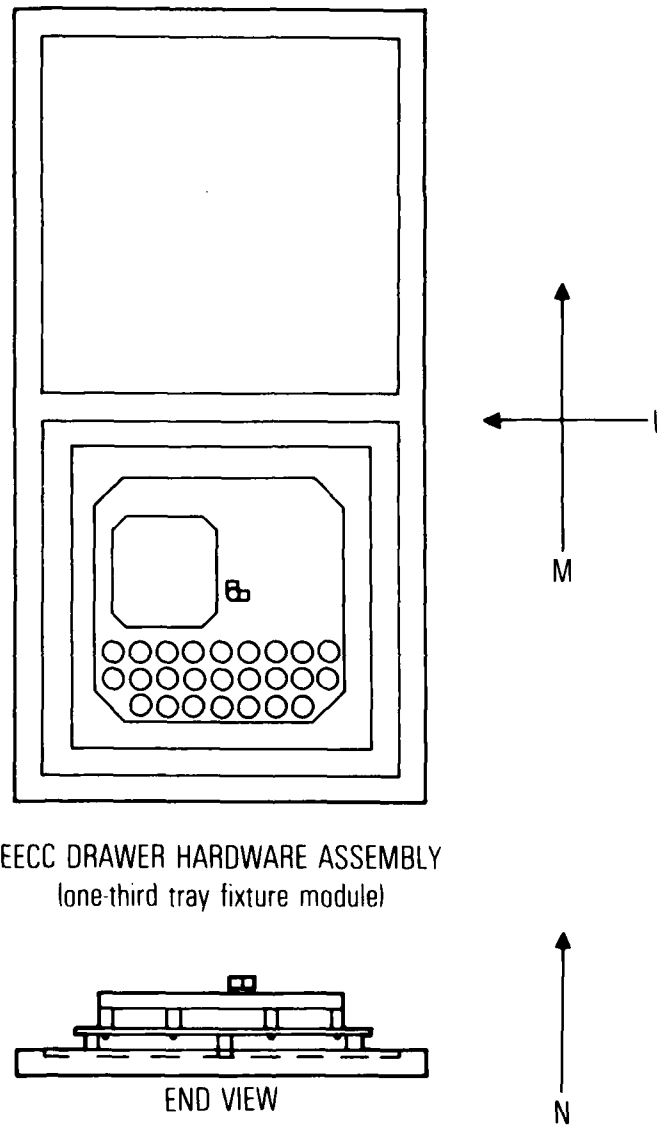
Figure 5. 6-in. Experiment Tray Assembly Accelerometer Location and Vibration Axis Designation

survey and sine qualification test were also completed. A structural failure occurred within the adaptor interface bracket after completing 45 sec of the required 1-min random vibration test. This failure and corrective action are discussed in Section 3. A visual inspection of the remaining pieces of hardware within module III and of the 6-in. tray itself produced no evidence of additional structural damage.

#### 1.3.3 EECC Drawer Hardware Assembly

The canister drawer sample retention hardware assembly was subjected to the prescribed vibration tests described in Section 2. The sample retention hardware and the method of mounting this hardware to the one-third module tray fixture were inspected after each axis of vibration. No evidence of structural damage was noted. Examination of the instrumentation records show that the magnitude of the response vibrations were within tolerance limits. Accelerometer location and vibration axis designation are shown in Figure 6.





EECC DRAWER HARDWARE ASSEMBLY  
(one-third tray fixture module)

Figure 6. EECC Drawer Hardware Assembly (one-third tray fixture module) Accelerometer Location and Vibration Axis Designation

## 2. TEST SPECIFICATIONS AND EQUIPMENT DESCRIPTION

### 2.1 PROCEDURE

A separate vibration procedure was used for each item tested. The following vibration test parameters provide a general overview of the qualification tests conducted.

1. Instrumented Package Response Test: 0.5 g-rms at 50 Hz
2. Sine Survey: 5 to 2000 Hz at 0.5 g peak
3. Sine Qualification

Input Amplitude	Frequency Range (Hz)	Sweep Rate
0.75-in.-D.A.	5-14	2 octaves/min
7.5 $\pm$ g-rms	14-20	2 octaves/min
1.5 $\pm$ g-rms	20-35	2 octaves/min

A graphic representation is shown in Figure 7.

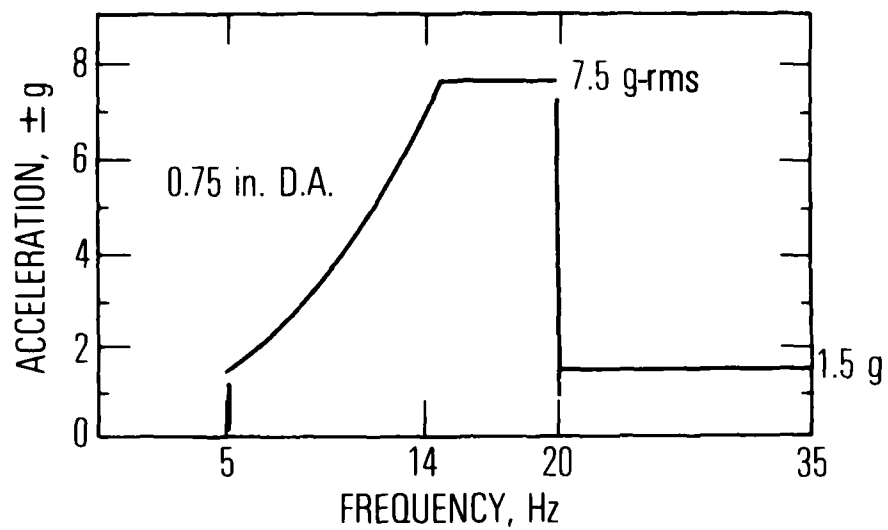
4. Random Vibration Qualification Test Input:

+ 6 dB/octaves between 10 and 60 Hz  
 $\pm$  3 dB/octaves between 60 and 300 Hz  
- 6 dB/octaves between 300 and 1600 Hz  
-24 dB/octaves between 1600 and 2000 Hz  
Test duration = 60 sec

A graphic representation is shown in Figure 8.

### 2.2 DOCUMENTATION

To validate that the qualification test conditions were adhered to, the response of the sinusoidal and random vibration input control accelerometers are presented in Figures 9 through 26. Because of the volume of hardware being tested and the fixturing required to properly retain the test hardware, a four-point vibration input control system was used when testing the 3- and 6-in. tray assemblies; a single-input control accelerometer was used for the one-third module test fixture. Only the number one input control accelerometer trace for each vibration test is presented.



DURATION = 2 OCT/min, 5 TO 35 Hz

Figure 7. Sinusoidal Vibration Conditions  
for Qualification Tests

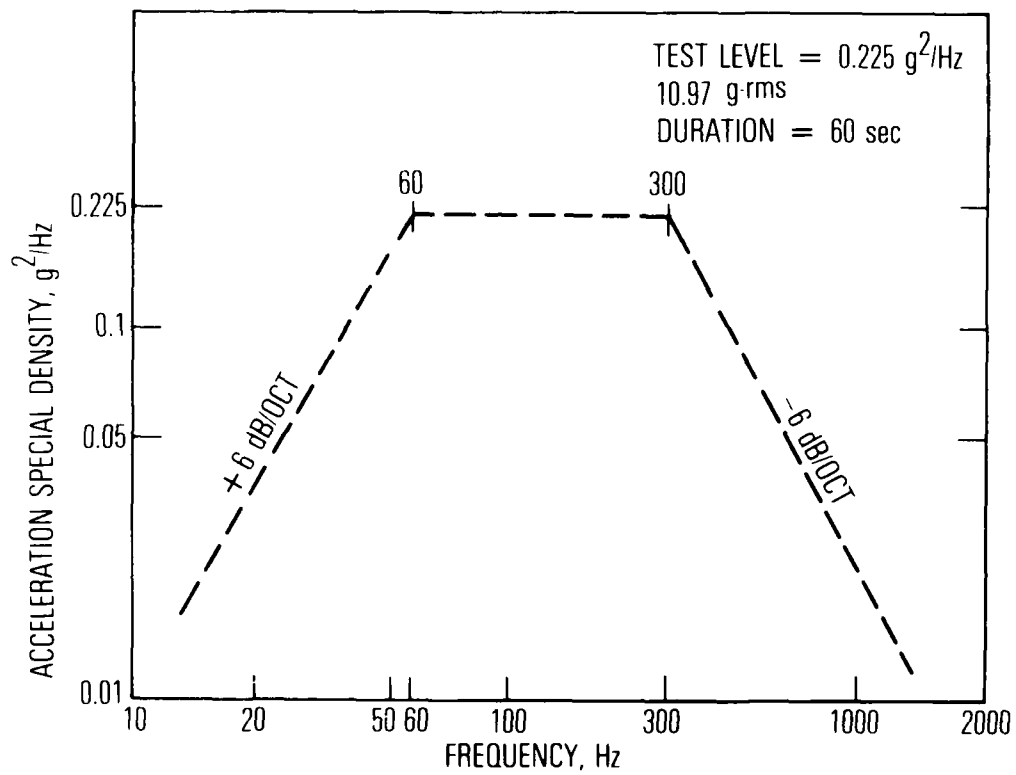


Figure 8. Random Vibration Conditions for Qualification Tests

STRUCTURAL DYNAMICS DATA ANALYSIS LABORATORY - G.S.F.C.

PROJECT DEFILAVIGLEY (S TRAY) AXIS L - R TARN NO. 20  
 ITEM INPUT #1 DATE 9-17-71

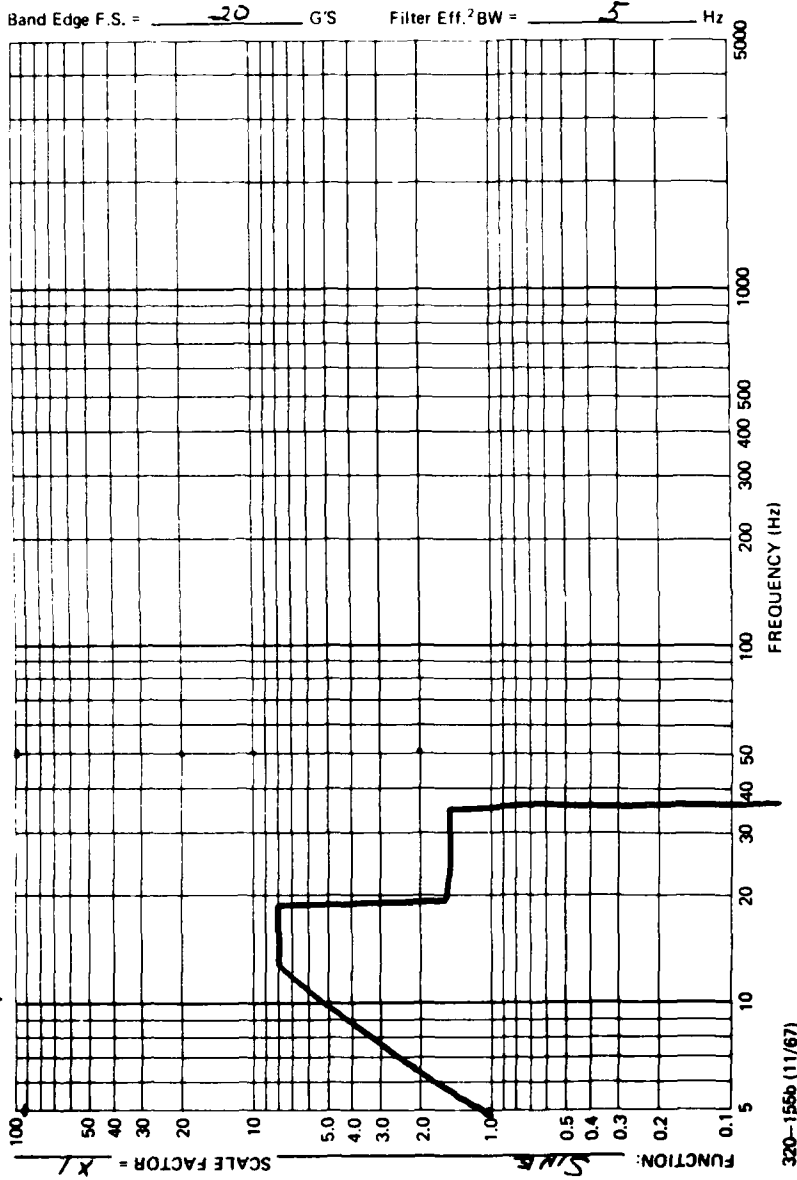


Figure 9. 3-in. Experiment Tray Sine Qualification Vibration Sweep,  
 L-Axis Input Accelerometer Response

7R

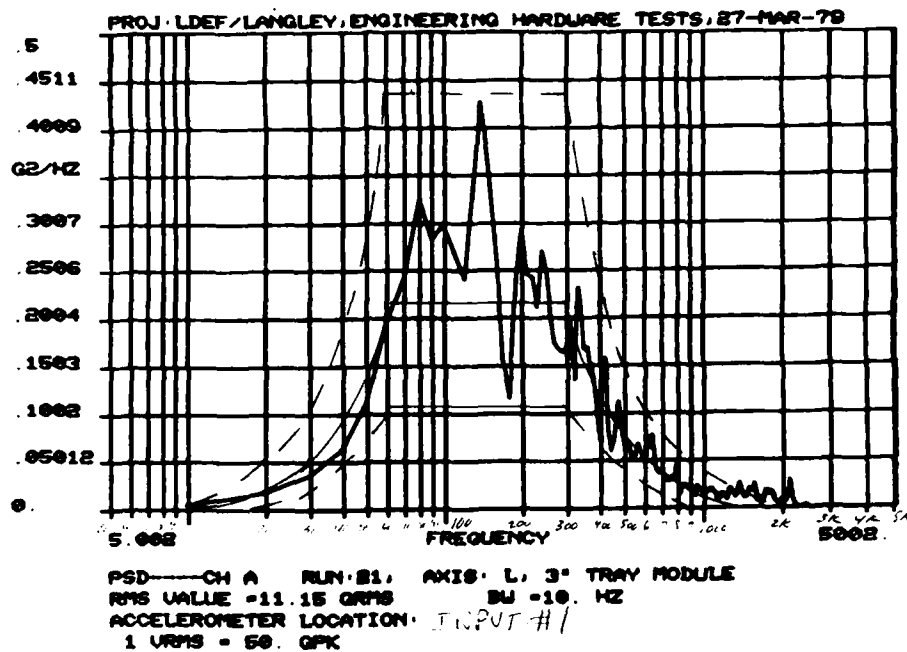


Figure 10. 3-in. Experiment Tray Random Vibration Qualification Test, L-Axis Input Accelerometer Response

STRUCTURAL DYNAMICS DATA ANALYSIS LABORATORY G.S.F.C.

PROJECT 1800/1800000 (3" tray) AXIS M - Run 16 TAR NO 32672  
 ITEM INPUT #1 DATE 3-26-72

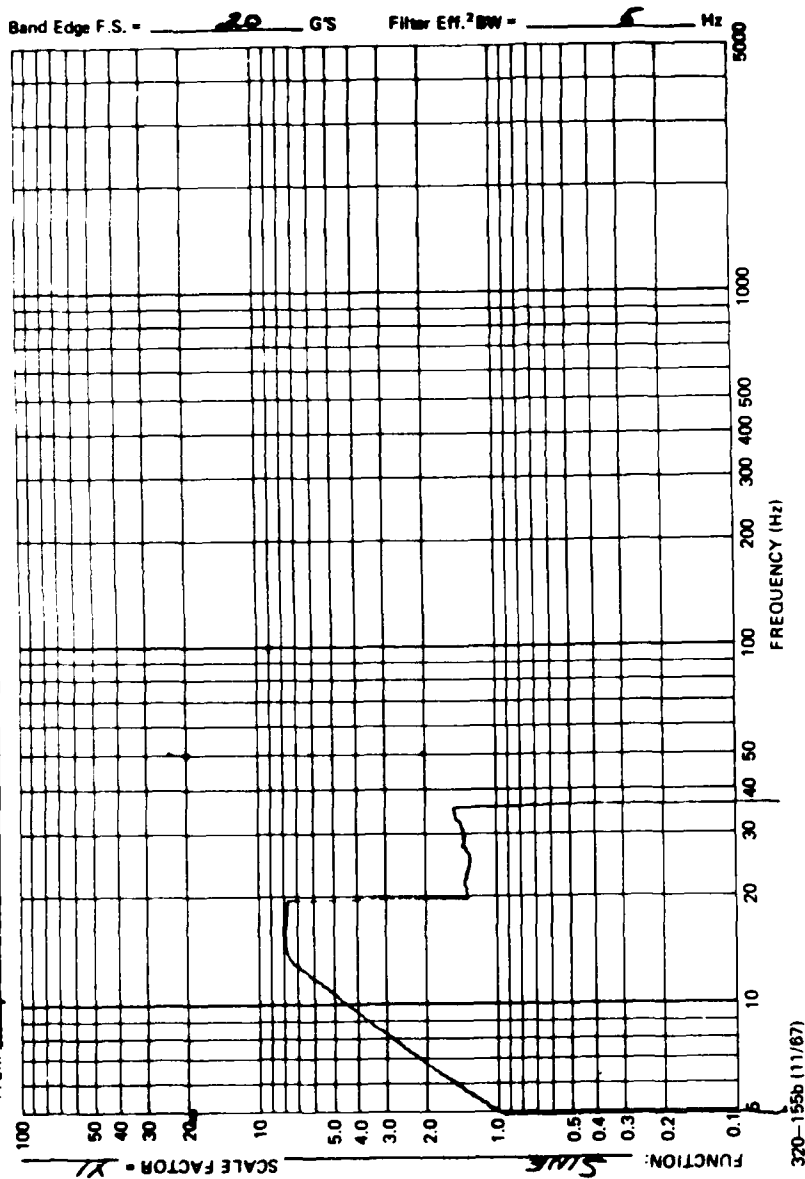


Figure 11. 3-in. Experiment Tray Sine Qualification Vibration Sweep, M-Axis Input Accelerometer Response

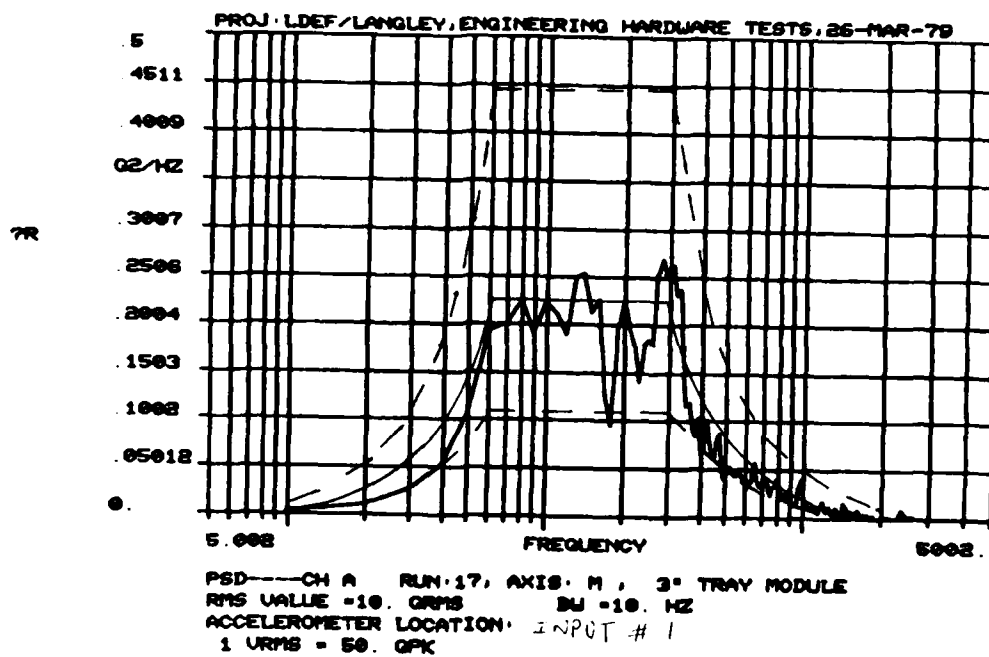


Figure 12. 3-in. Experiment Tray Random Vibration Qualification Test, M-Axis Input Accelerometer Response



STRUCTURAL DYNAMICS DATA ANALYSIS LABORATORY - G.S.F.C.

PROJECT DEFKANGLEY (3" Tray) AXIS N RUN 38 TAR NO 3-28-79  
 ITEM INPUT #1 DATE 3-28-79

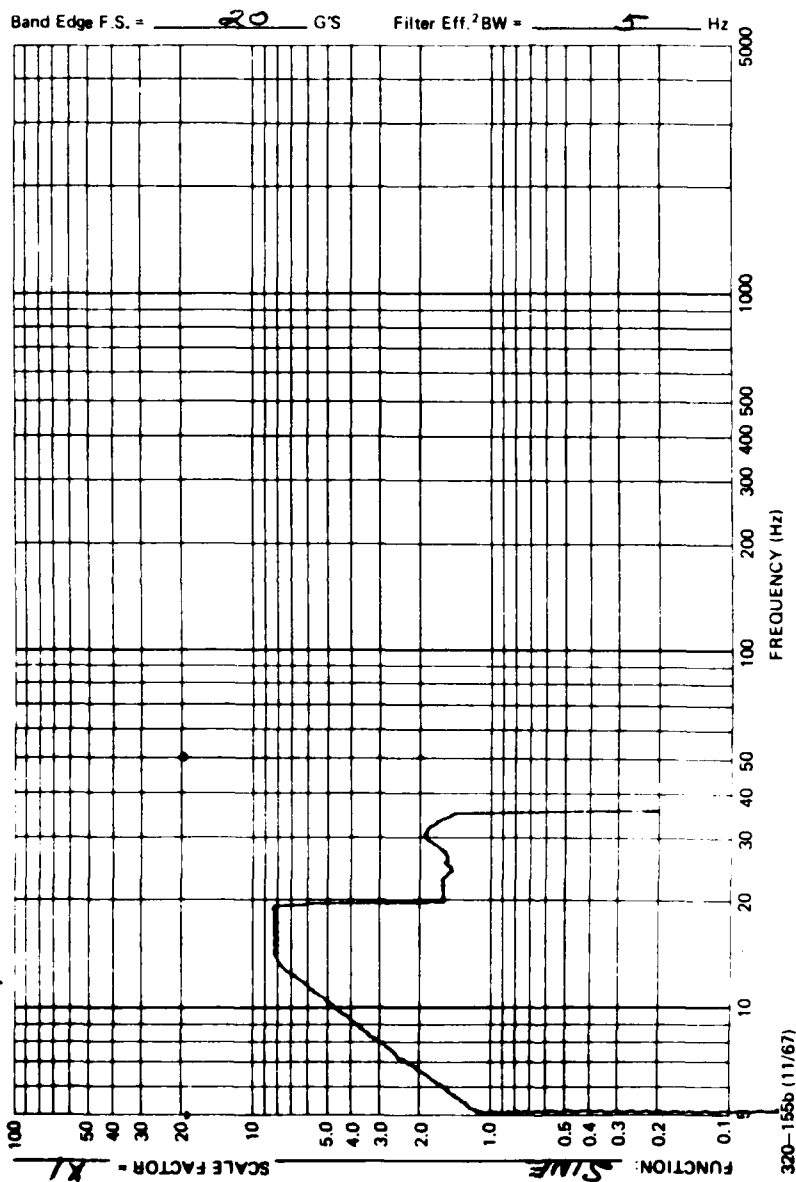


Figure 13. 3-in. Experiment Tray Sine Qualification Vibration Sweep, N-Axis Input Accelerometer Response

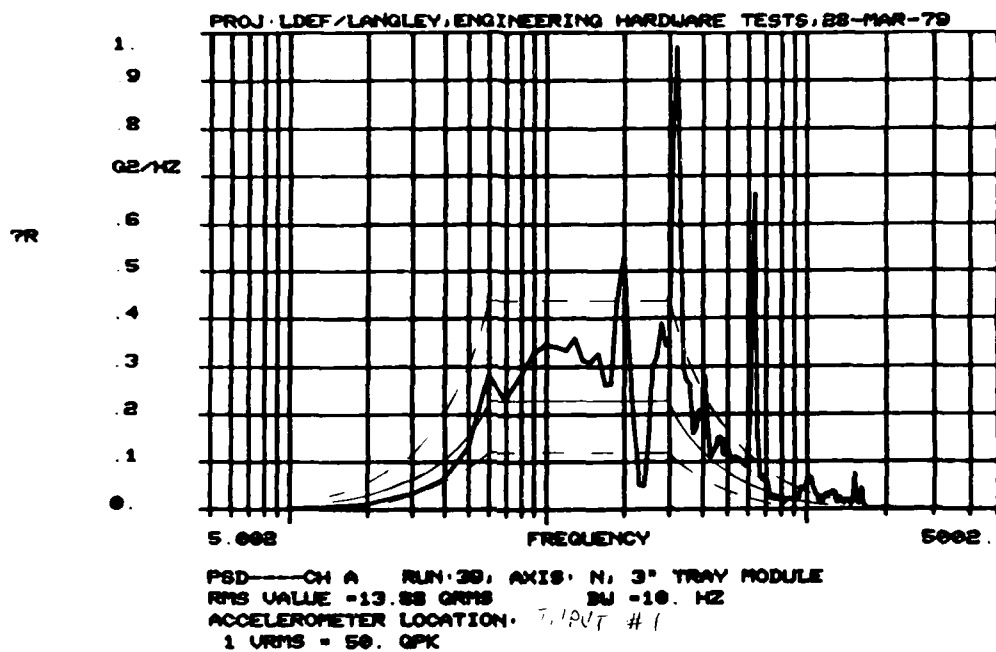


Figure 14. 3-in. Experiment Tray Random Vibration Qualification Test, N-Axis Input Accelerometer Response

STRUCTURAL DYNAMICS DATA ANALYSIS LABORATORY - G.S.F.C.

PROJECT LADE/LANGLEY (6" TRAY) XIS 1 - RUN 24 TAR NO. 3-27-79  
 ITEM INPUT #1 DATE 3-27-79

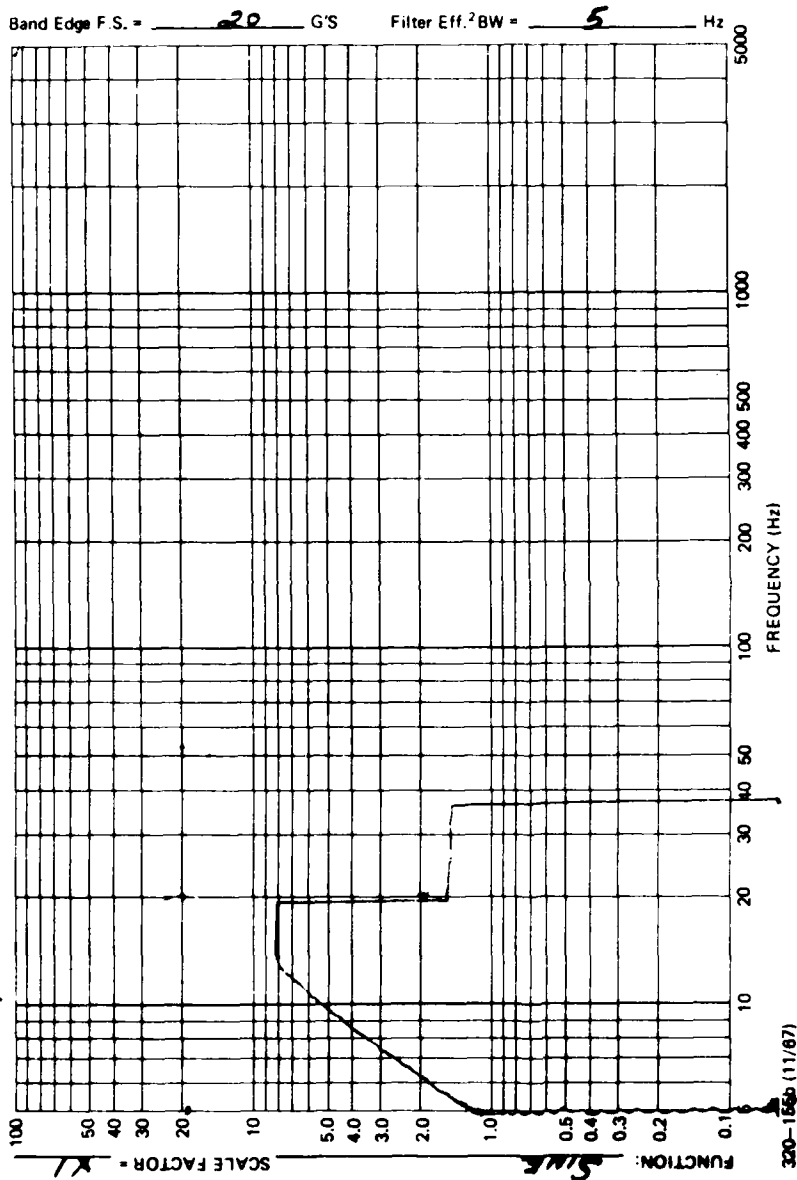


Figure 15. 6-in. Experiment Tray Sine Qualification Vibration Sweep,  
 L-Axis Input Accelerometer Response

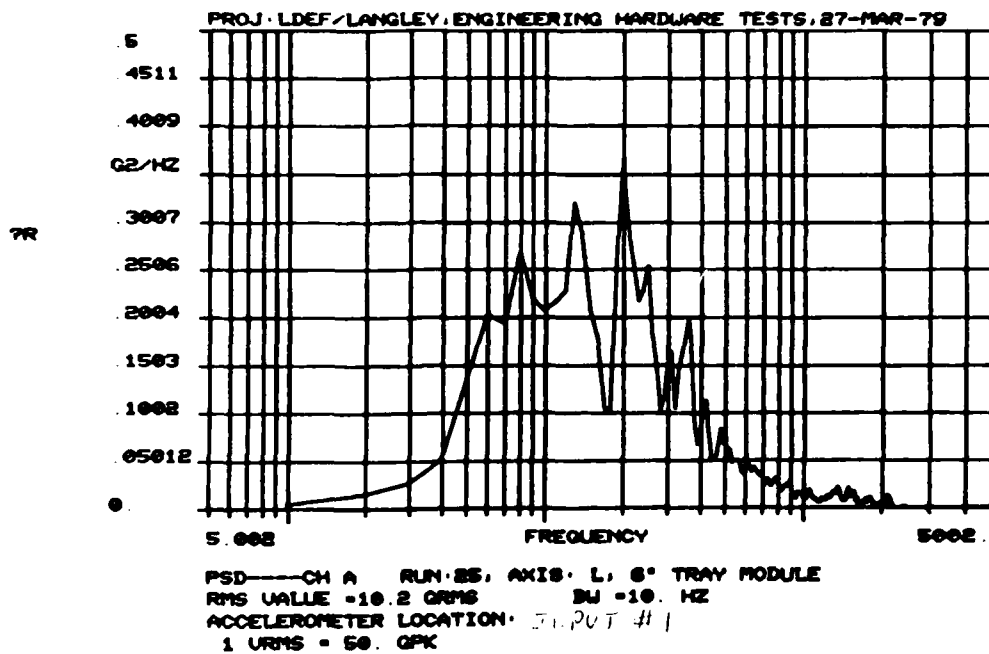


Figure 16. 6-in. Experiment Tray Random Vibration Qualification Test, L-Axis Input Accelerometer Response

STRUCTURAL DYNAMICS DATA ANALYSIS LABORATORY - G.S.F.C.

PROJECT LDER/LANGLEY (6" TRAY) AXIS M-RUN 2P TAR NO 3-27-79  
 ITEM INPUT # 1 DATE

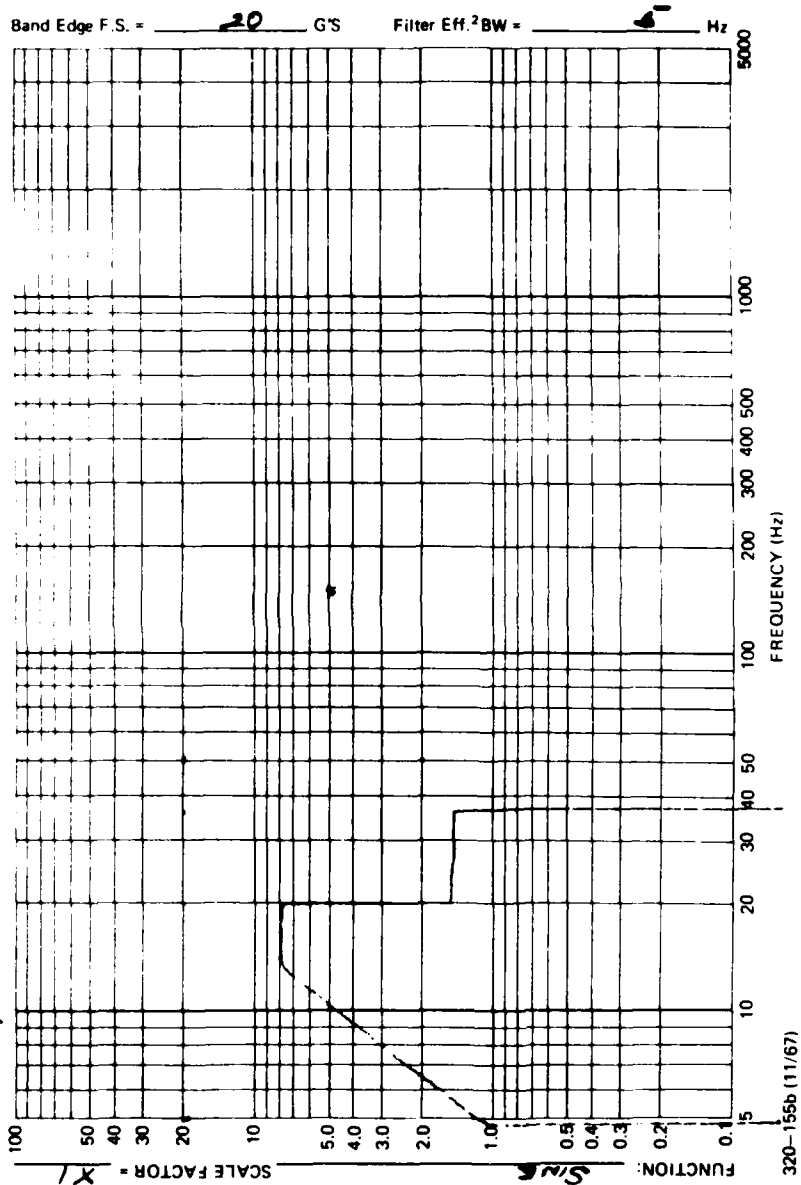


Figure 17. 6-in. Experiment Tray Sine Qualification Vibration, M-Axis  
 Input Accelerometer Response

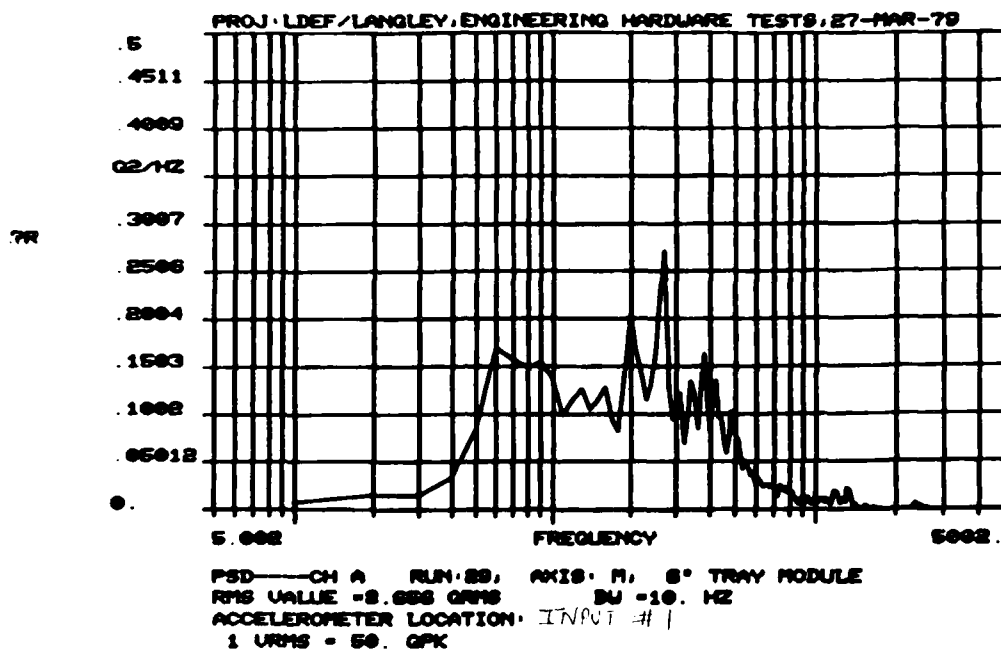


Figure 18. 6-in. Experiment Tray Random Vibration Qualification Test, M-Axis Input Accelerometer Response

STRUCTURAL DYNAMICS DATA ANALYSIS LABORATORY - G.S.F.C.

PROJECT LDEE/LAVOUEY (6" TRAY) AXIS N- RUN 23 TAR NO. 3-28-79  
 ITEM INPUT #1 DATE

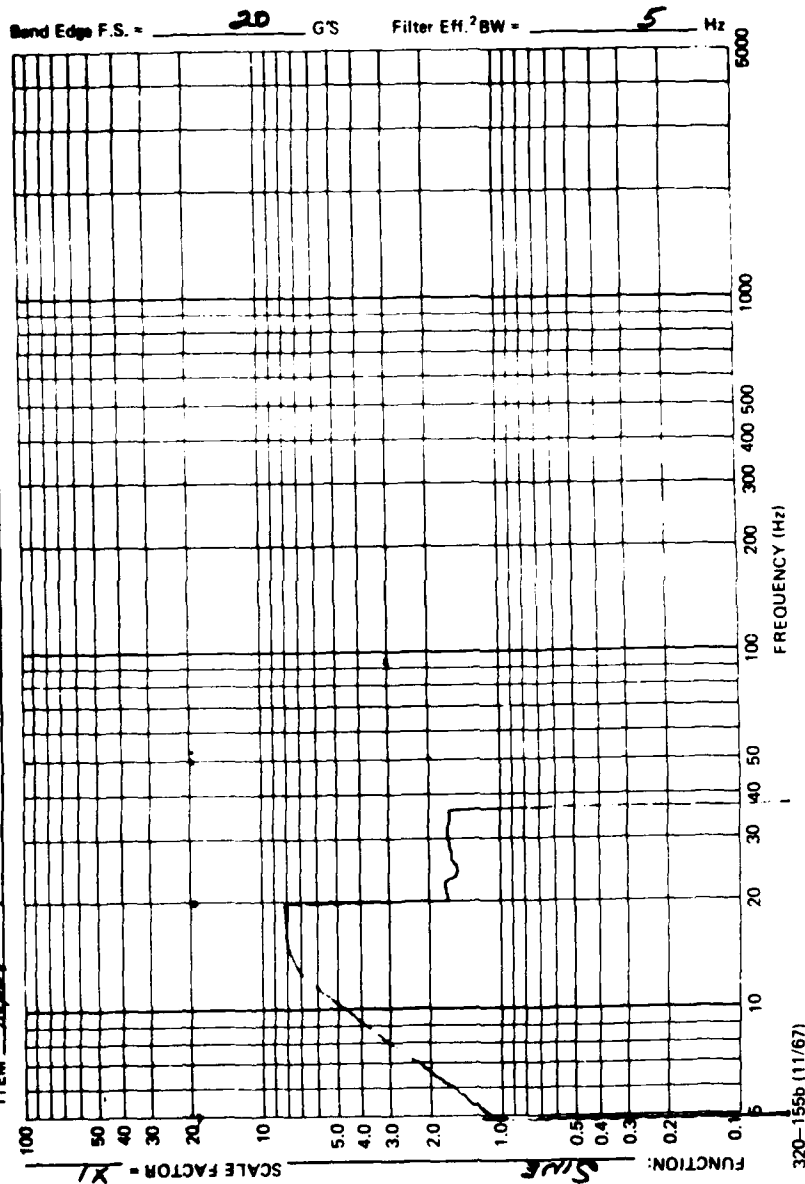


Figure 19. 6-in. Experiment Tray Sine Qualification Vibration Sweep,  
 N-Axis Input Accelerometer Response

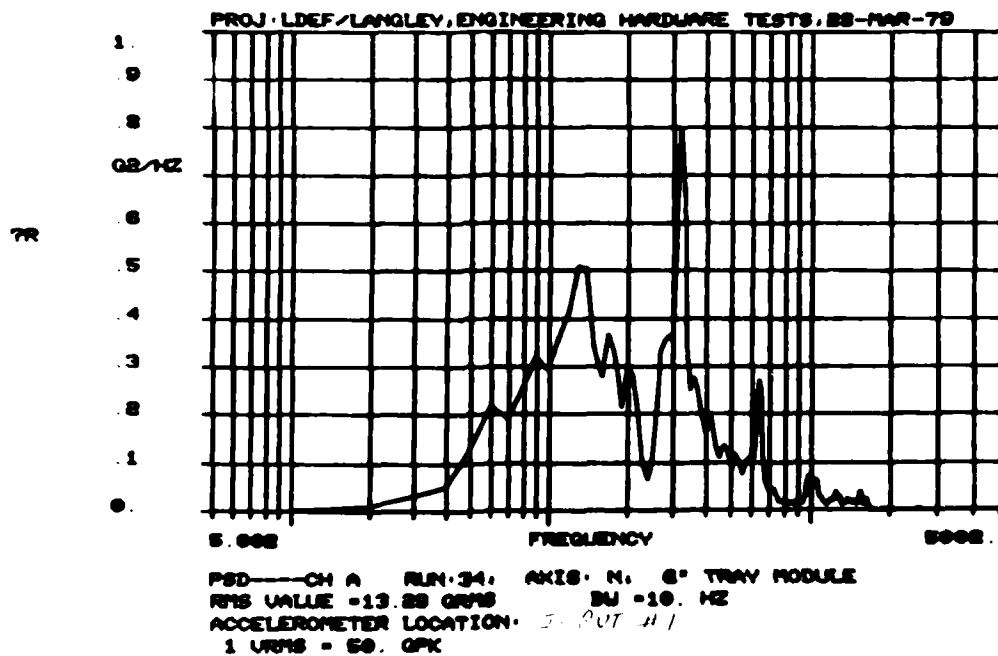


Figure 20. 6-in. Experiment Tray Random Vibration Qualification Test, N-Axis Input Accelerometer Response



STRUCTURAL DYNAMICS DATA ANALYSIS LABORATORY - G.S.F.C.

PROJECT LEOP/LANGLEY (3 TRAY) AXIS L - RUN 3 TAR NO. 3-27-73  
 ITEM INPUT DATE

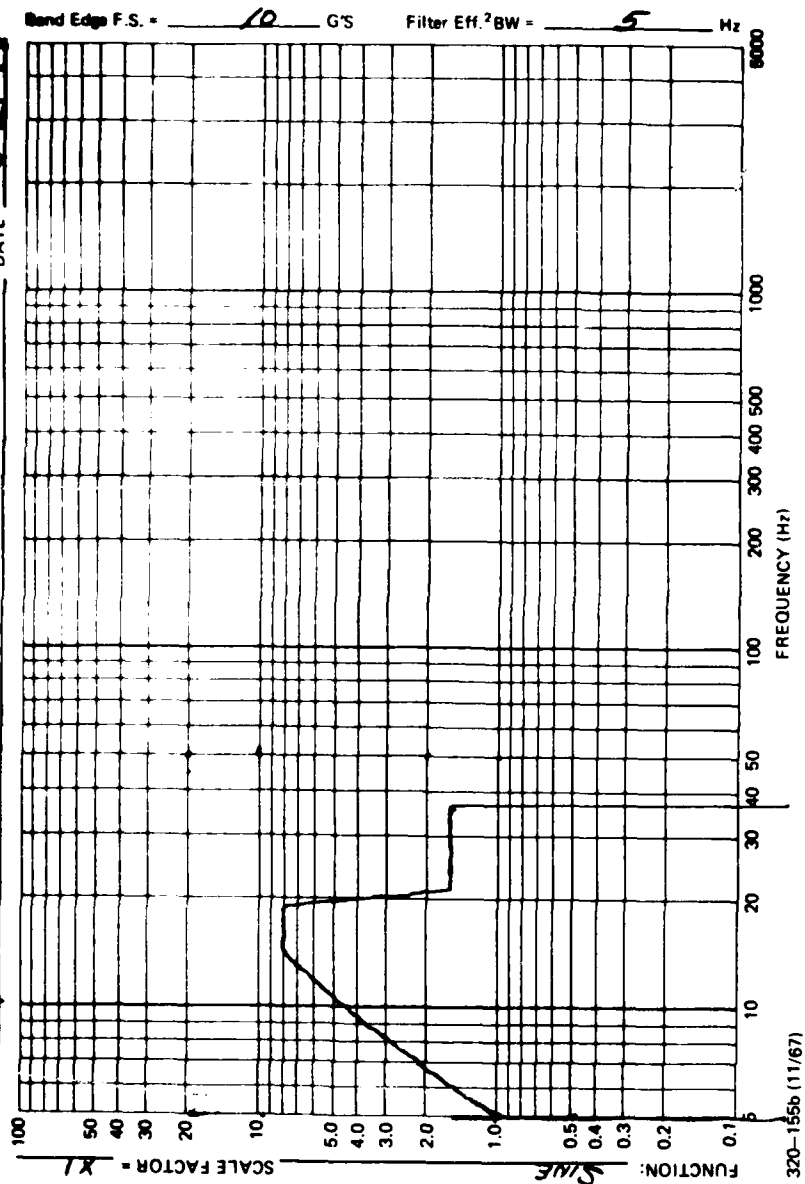


Figure 21. EECC Drawer Hardware Assembly Sine Qualification Vibration Sweep, L-Axis Input Accelerometer Response

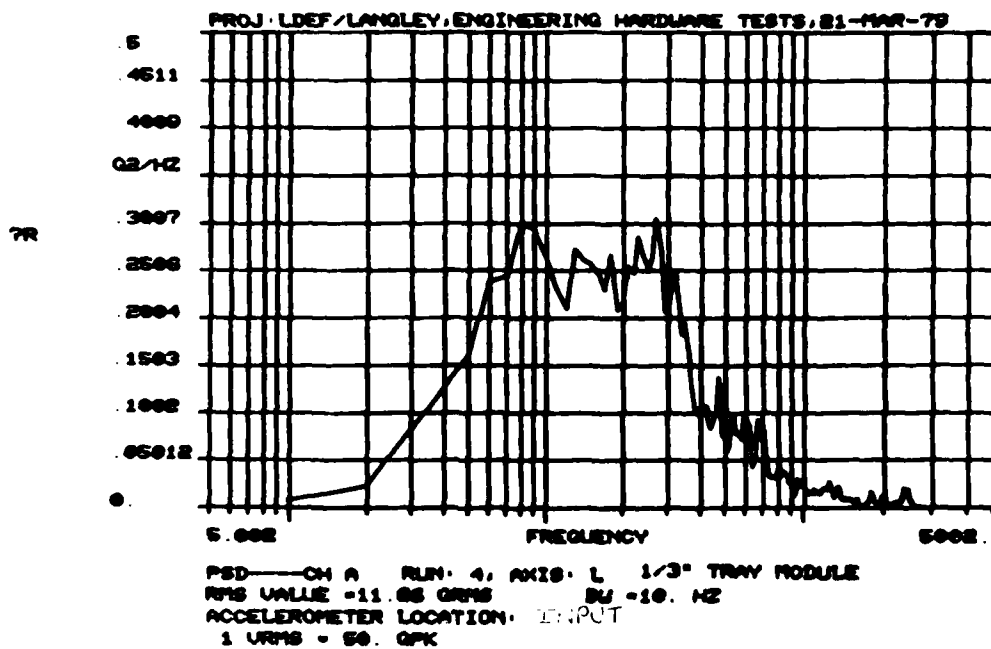


Figure 22. EECC Drawer Hardware Assembly Random Vibration Qualification Test, L-Axis Input Accelerometer Response

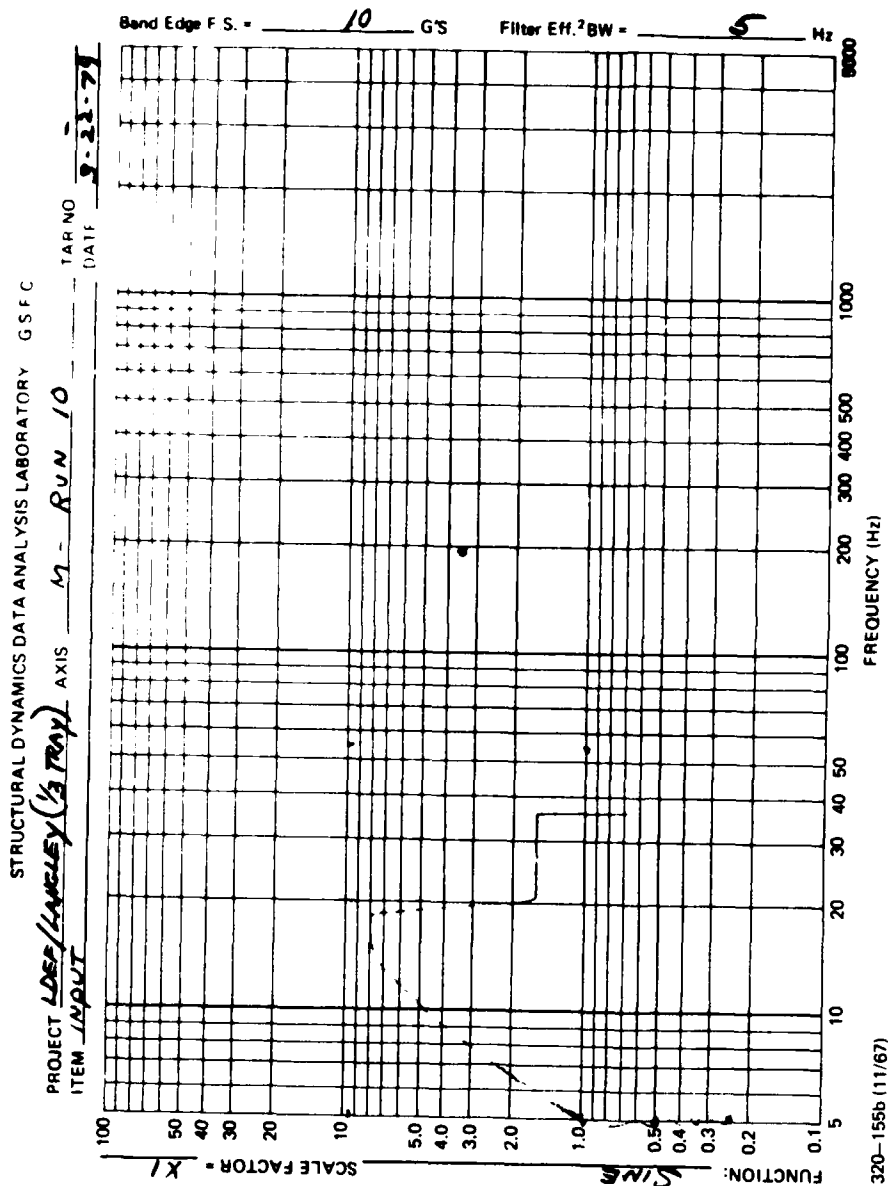


Figure 23. EECC Drawer hardware Assembly Sine Qualification Vibration Sweep, M-Axis Input Accelerometer Response

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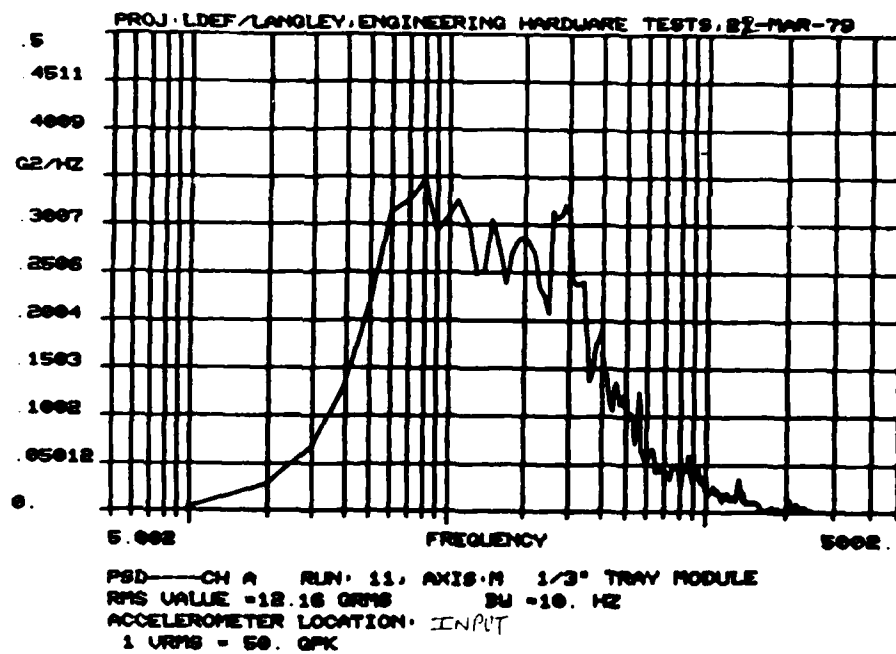


Figure 24. EECC Drawer Hardware Assembly Random Vibration Qualification Test, M-Axis Input Accelerometer Response

STRUCTURAL DYNAMICS DATA ANALYSIS LABORATORY G.S.F.C.

PROJECT DRF/Langley (3 tray) AXIS N- Run 43 TAR NO 8-28-79  
 ITEM INPUT #1 DATE

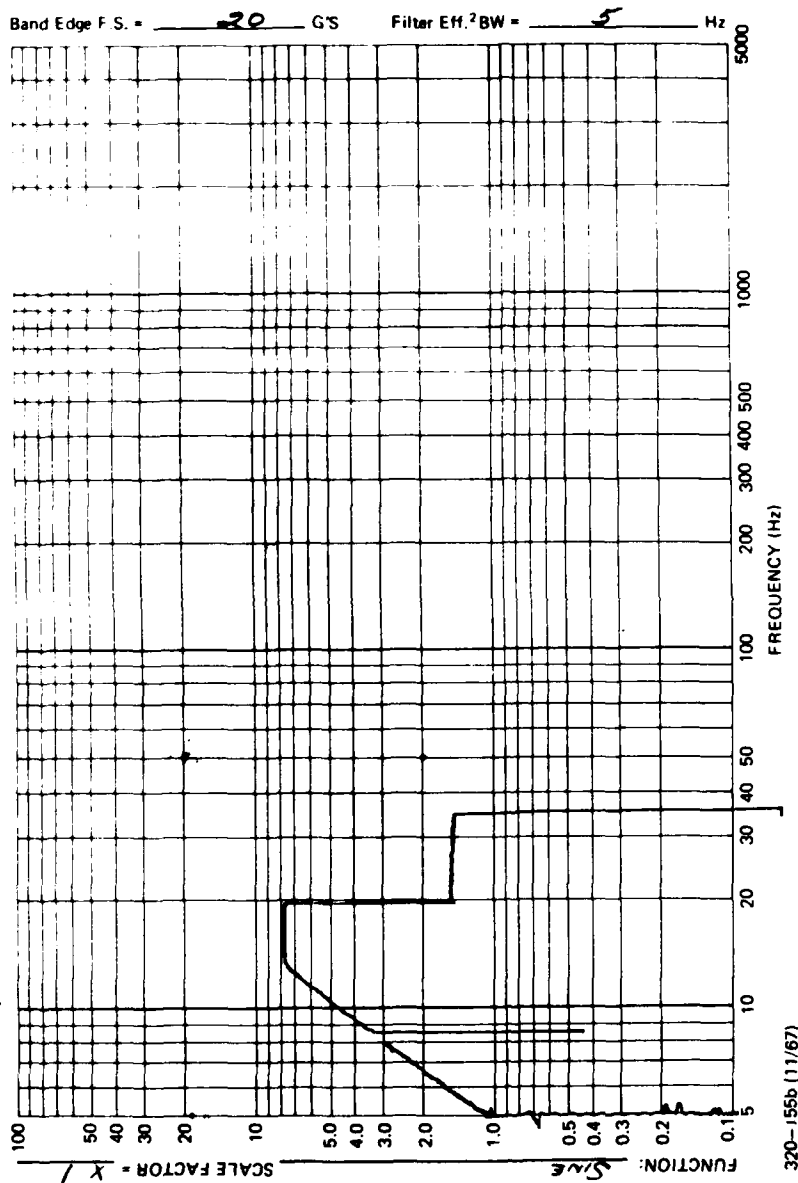


Figure 25. EECC Drawer Hardware Assembly Sine Qualification Vibration Sweep, N-Axis Input Accelerometer Response

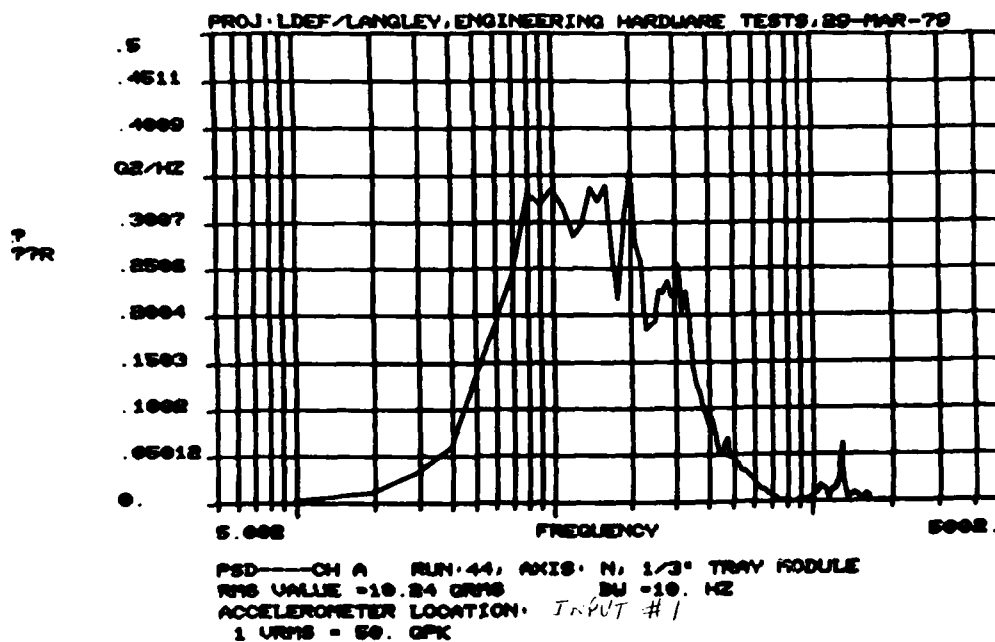


Figure 26. EECC Drawer Hardware Assembly Random Vibration Qualification Test, N-Axis Input Accelerometer Response

## 2.3

EQUIPMENT DESCRIPTION\*

1. Control Units: Digital controlled vibration testing system,  
Ling Electronics, and analog control unit
2. Vibration Exciter: MB Model 220, 35,000 force lb, and  
Ling Model C125, 10,000 force lb
3. Moving Table Assembly: Hydrostatic bearing table
4. Instrumentation capability:

	Channels	
	C220	C125
Acceleration	70	38
Strain	48	10
Magnetic Tape	90	60
Oscillograph	60	48

\*Vibration testing was conducted by the Vibration and Acoustics Test Section, Goddard Space Flight Center.

### 3. DISPOSITION OF TEST ANOMALY

#### 3.1 FAILURE MODE

The composite materials experiment located in the 6-in. tray, module III position, incurred a structural failure. The failure occurred within the adaptor interface bracket. This bracket provides the interface connection between the sample retention hardware and the thermal isolation standoffs.

The adaptor interface bracket was constructed of five extruded aluminum 6061-T6 channels welded together in an interlocking manner. A multiple-weld failure was noted. Posttest examination of the bracket shows tack weld construction at the channel interfaces.

#### 3.2 CORRECTIVE ACTION

The adaptor bracket, Aerospace Design Drawing No. 008884, was revised. The replacement bracket was milled from solid 6061-T6 aluminum stock. The minimum thickness across any portion of the assembly is now 0.190 in. compared to 0.062 in.



#### REFERENCES

1. C. E. Kiser, "Vibration Test Procedure for The Aerospace Corporation Spacecraft Materials Experiments 3" Tray Unit," NASA LDEF Experiment Number M0003 NASA, Langley Research Center, Hampton, Va. (16 February 1979).
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## LABORATORY OPERATIONS

The Laboratory Operations of The Aerospace Corporation is conducting experimental and theoretical investigations necessary for the evaluation and application of scientific advances to new military concepts and systems. Versatility and flexibility have been developed to a high degree by the laboratory personnel in dealing with the many problems encountered in the nation's rapidly developing space and missile systems. Expertise in the latest scientific developments is vital to the accomplishment of tasks related to these problems. The laboratories that contribute to this research are:

Aerophysics Laboratory: Launch and reentry aerodynamics, heat transfer, reentry physics, chemical kinetics, structural mechanics, flight dynamics, atmospheric pollution, and high-power gas lasers.

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Materials Sciences Laboratory: Development of new materials; metal matrix composites and new forms of carbon; test and evaluation of graphite and ceramics in reentry; spacecraft materials and electronic components in nuclear weapons environment; application of fracture mechanics to stress corrosion and fatigue-induced fractures in structural metals.

Space Sciences Laboratory: Atmospheric and ionospheric physics, radiation from the atmosphere, density and composition of the atmosphere, aurorae and airglow; magnetospheric physics, cosmic rays, generation and propagation of plasma waves in the magnetosphere; solar physics, studies of solar magnetic fields; space astronomy, x-ray astronomy; the effects of nuclear explosions, magnetic storms, and solar activity on the earth's atmosphere, ionosphere, and magnetosphere; the effects of optical, electromagnetic, and particulate radiations in space on space systems.

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